DØ Note 3724

Fallback Options for the DØ Upgrade

The DØ Collaboration

January 31, 2000

Introduction

During September 1999, DØ established a new and, in our opinion, realistic schedule for completing the upgrade of the detector for Run II. During this exercise our completion date slipped from July 1999 to February 2001. Since that time we have monitored this schedule on a bi-weekly basis, moved and allocated resources within the collaboration and Fermilab to areas where we see problems develop, established a set of reportable milestones by which progress can be tracked by DØ and the Fermilab directorate, strengthened the DØ management team and worked to generate schedule contingency by examining the installation sequence of the detector. The results of these efforts have been a very detailed understanding of our schedule and the creation of about two months of contingency for the arrival of the silicon system. After establishing this schedule, monitoring it and working with it for four months, we feel more confident than ever that we indeed can deliver the complete detector in time for the start of Run II on March 1, 2001. However, confidence is not enough, and we wish to make sure that at that date we indeed have a detector that can live in the operating conditions of Run II and address the physics of Run II. To achieve this we have developed fallback options for the remaining time between now and February 2001 which are derived from identifying areas of risk in the detector construction and assembly. Based on these identified risk areas we have defined fallback plans/options which would be executed if the risk were indeed to materialize. In December 1999 the laboratory directorate requested that we develop such fallback options. Although we started with some reluctance, DØ has now fully embraced this concept. This exercise has forced us to consider things that might go wrong and define alternative paths for such cases now. In the end this is sure to lead to a more physics-ready detector by March 2001, a date which we consider to be absolutely fixed.

Charge

On December 20, 1999, the DØ Spokesmen and Project Managers were requested by the Directorate and the Project Management Group to provide the following information:

> "By January 31, 2000, we wish to have identified fallback plans and descope options. By May 2000 we want to have in place fully detailed plans including fallback positions and descoping so that we can decide to follow them if necessary to maintain with certainty the March 1, 2001, milestone."

> "In order to develop these plans we ask that you undertake to do a schedule risk analysis for all subsystems including "installation and commissioning." This analysis should answer the following

questions: What can go wrong? What is the likelihood that it will go wrong? What is the schedule impact if it goes wrong? This analysis should lead to a good understanding of the schedule risks for each subsystem. Perhaps this already exists. "

"For all subsystems and concentrating on those subsystems with the highest schedule risk identify activities that could be delayed or components that could be deferred in order to recover schedule delays should anything actually go wrong? An itemized list of these fall back positions and descope options should be made for each subsystem. The amount of time to be gained in the schedule should be estimated for each option. Examples that come to mind are the delay of some channels of read-out electronics and staging of the silicon detector. The schedule risk analysis and the lists of options and fallback positions should be presented to the laboratory by January 31, 2000. "

This document addresses that request.

Our Strategy

We have chosen to explore the following types of fallback position, in approximately descending order of desirability:

1. Gain schedule contingency by re-optimization of the installation and commissioning process, both in terms of the order in which tasks are done and the way in which they are done.
2. Prioritize the order in which detector construction work is carried out, so that the last items delivered are those which can be deferred or delayed if necessary.
3. Understand which parts of the detector could be deferred, and installed after roll-in (staging).
4. Understand the physics impact of actually reducing the scope of the detector, which could take the form of choosing to deploy less than perfect devices, or ultimately of omitting parts completely.

The collaboration has been involved in this process throughout:

- through well attended weekly meetings (starting January 12, 2000) where ideas and simulation studies are presented
- through web pages including relevant documents and discussion
- by the establishment of a Contingency Planning Panel (chaired by Ken Johns), whose role is to oversee the process of arriving at agreed upon plans and documents, and to advise the spokesmen and project managers

We intend to maintain this process through the continuing stages of the fallback discussion, at least up to the point where we have an agreed-upon plan to be implemented.

Throughout this process, we have tried to maintain the viewpoint that we will maximize our chances of success by understanding the choices we have at any given point in time, and that when faced with problems, we should be able to know how to react. Our goal very definitely remains the installation of the complete DØ detector, on schedule and ready for beam by March 1, 2001. We believe that this goal is an attainable one. It should be noted that the current DØ schedule has DØ ready for beam on February 7, 2001.

Fallback Options by Subsystem

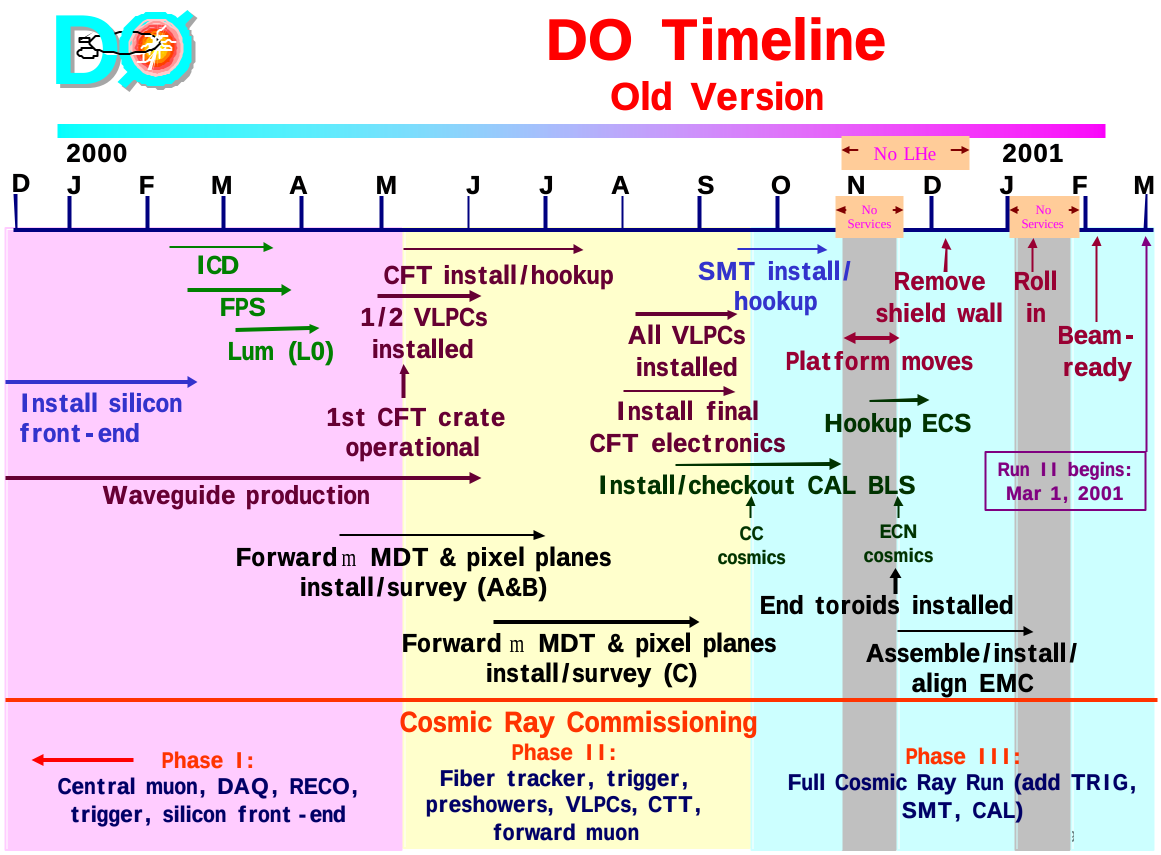
The following are areas of concern, and possible responses, listed by subsystem. We wish to emphasize that many (perhaps all) of these options need further study as to their physics impact, engineering feasibility, ultimate desirability, and the decision points. We are not committing to carry out any of these options, nor will we necessarily limit ourselves to these if other choices become apparent as we look at these questions more deeply.

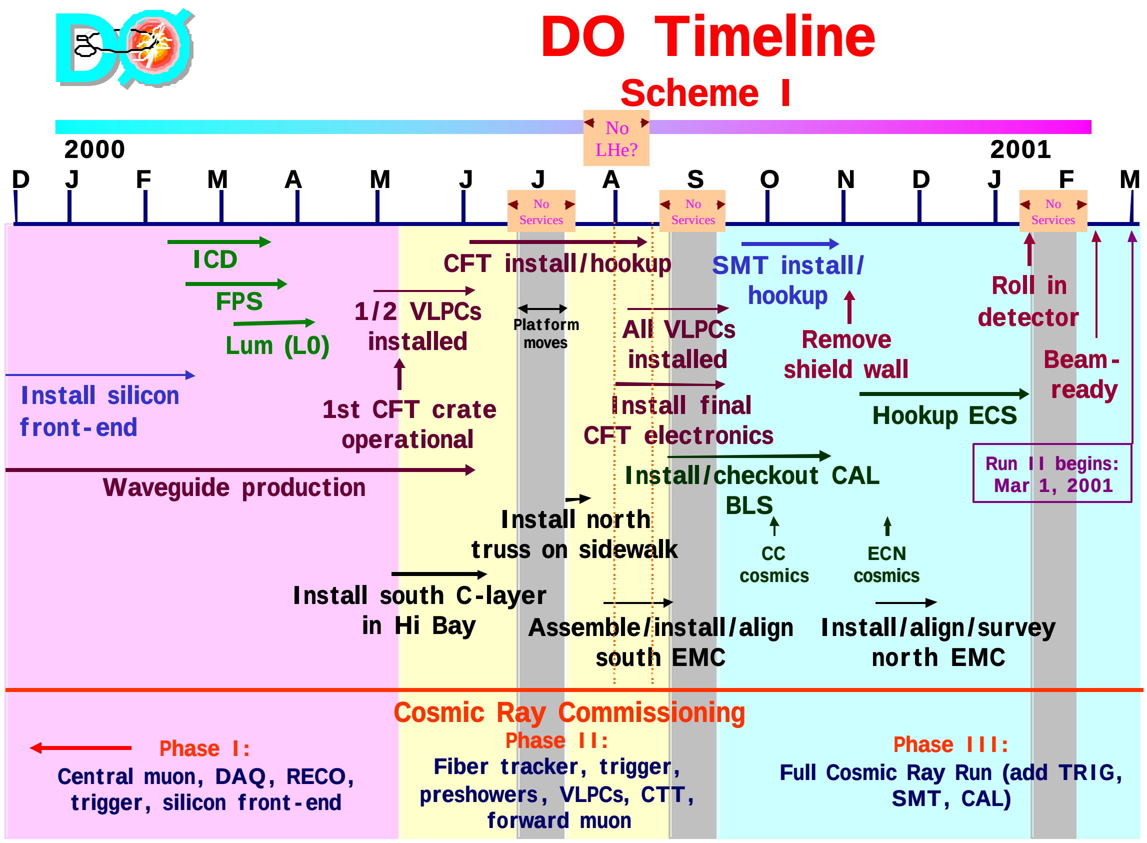
Installation and Commissioning

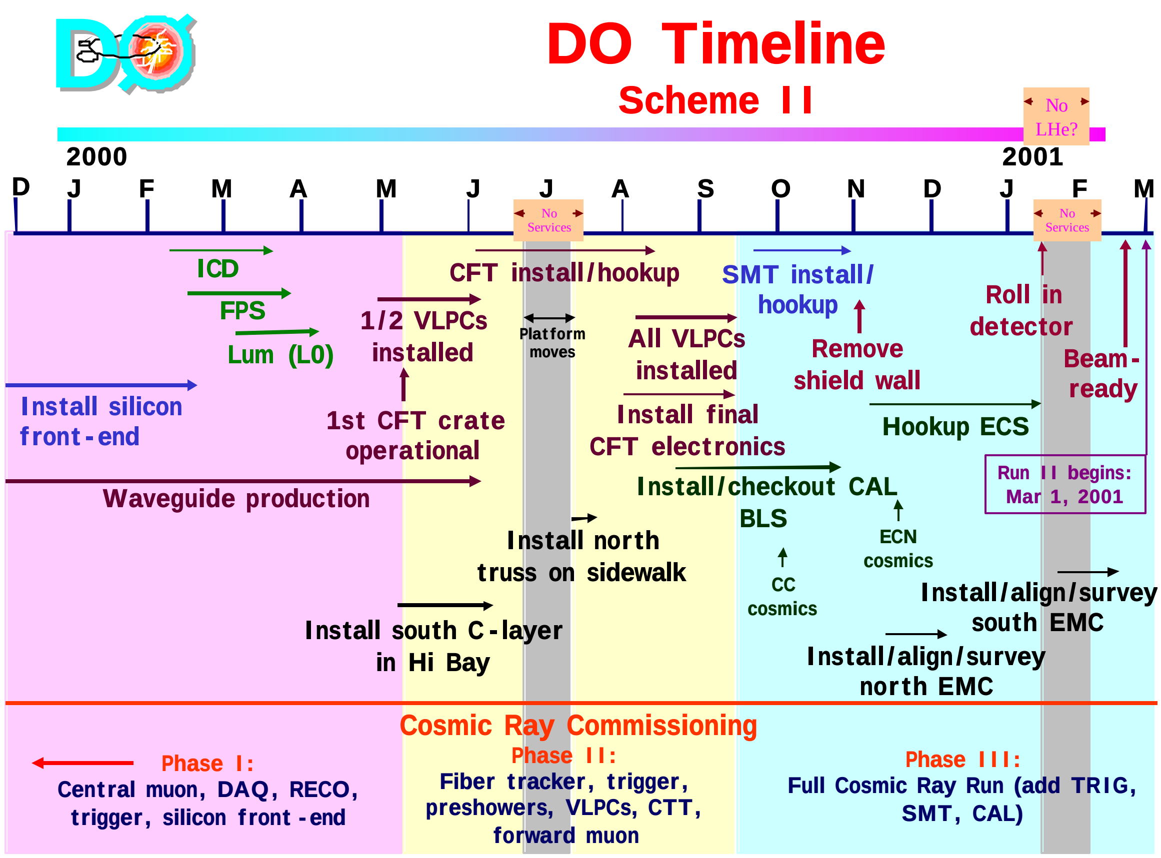
After the Installation and Commissioning Review of DØ on December 7 & 8, 1999, the installation sequence and schedule were thoroughly reviewed with two primary goals in mind: to introduce more uninterrupted commissioning time during the end game, and to create contingency for the delivery of the silicon tracker. The resulting revised schedule, with fallback options, was presented at the January 20, 2000 PMG and these presentations can be found on:
http://DØserver1.fnal.gov/Projects/UpgradeProject/PMG_presentations/index_PMG.html

Here we display these schedules in a graphical form, as shown at the PMG, but they are implemented in Microsoft Project as well. The graphical display shows the time between December 1999 and March of 2001. The vertical dark gray bars in these graphs indicate times when the detector platform is moving.

The following is the DØ baseline schedule (labeled as "Old Version") as of the beginning of December 1999:




DO Timeline
Scheme I
No LHe?
2000
2001
D J F M A M J J A S O N D J F M
No Services
No Services
No Services
ICD
FPS
Lum (L0)
Install silicon front-end
Waveguide production
1/2 VLPCs installed
1st CFT crate operational
CFT install/hookup
Platform moves
All VLPCs installed
Install final CFT electronics
Install north truss on sidewalk
Install south C-layer in Hi Bay
Assemble/install/align south EMC
SMT install/hookup
Remove shield wall
Install/checkout CAL
BLS
CC cosmics
ECN cosmics
Install/align/survey north EMC
Roll in detector
Beam-ready
Hookup ECS
Run II begins: Mar 1, 2001
Cosmic Ray Commissioning
Phase I:
Central muon, DAQ, RECO, trigger, silicon front-end
Phase II:
Fiber tracker, trigger, preshowers, VLPCs, CTT, forward muon
Phase III:
Full Cosmic Ray Run (add TRIG, SMT, CAL)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New “Scheme I”

The current default DØ schedule is displayed in the next graph and is labeled “Scheme I”. The major new features of this schedule are:

1. During the shutdown of the Tevatron (planned for August 1-15, see Appendix A), between the engineering run and commissioning run of the Tevatron, we plan to install the south muon EMC truss, with the C layer MDT and pixel detectors mounted, in the Collision Hall. This requires coordination with the Beams Division and the current estimate is that it will take 3 weeks from the time the Tevatron shuts down to when it can start up again. This time is dominated by the manipulation of the low-beta quadrupoles, and their attendant shielding. We estimate that one week of contingency should be added to this. During this time the following needs to be done:
    a. take down part of the DØ shield wall,
    b. retract the south low β quadrupole into the tunnel,
    c. install the south muon truss,
    d. put the low β quadrupole back into position, put shield wall back up.
2. The north truss is moved down to the assembly pit sidewalk in early July; the north C layer MDTs and pixels are mounted while this truss is in the pit.
3. There are a total of three platform moves, two of which precede the final roll-in of the detector into the Collision Hall.
4. Uninterrupted commissioning starts in September of 2000, and proceeds as the subdetectors, electronics, and trigger elements arrive, with no interruption from disconnection of cryogenic or other services. This commissioning period ends when the detector rolls into the Collision Hall, giving a total of more than four months of commissioning time during the end game.

Implications of the Scheme I schedule:

I. It should be pointed out that this schedule ties the DØ schedule to the Tevatron schedule: if the end of the engineering run (start of shutdown) slips, the DØ schedule will slip. This is because we will be waiting with the south truss on the south sidewalk in the assembly pit and be in a position where no tracking detectors can be installed in DØ. A two week slip in the August 1 shutdown will delay the installation of the silicon at DØ.

II. A final decision on the exact timing of the Tevatron shutdown between engineering and commissioning run has to be taken by June 1, 2000 in order not to effect the DØ schedule. The Beams Division has told us that this leaves ample time for them to prepare for the early installation of the south truss.

III. We rely on the Tevatron commissioning run ending at the end of October 2000.

IV. The fiber tracker installation window closes on June 26, 2000 and opens up again on September 8, 2000.

V. Disconnection of the liquid helium engines occurs once during the early July/beginning of August time frame. All services – power, water, cryogenics – must be disconnected during platform moves. We are working on a scheme by which the south truss can be brought down to the south sidewalk without disconnecting the helium engines, which would buy us a significant amount of commissioning time, and prevent the diversion of a significant amount of manpower.

Given this default schedule we will have created about two months of contingency for the delivery of the silicon tracker, while adding a week to the current completion date, moving it to February 13, 2001. In order to take advantage of this contingency, we must hookup the south End Calorimeter (and the preshower and ICD mounted on it) while the detector is in the Collision Hall.

New “Scheme II”

If for one reason or another (accelerator delays, production delays, etc.) it is not possible to install the south truss in the collision hall during the shutdown between the Tevatron engineering and commissioning run, the fallback position is the schedule labeled “Scheme II”. The differences between Scheme I and Scheme II are:

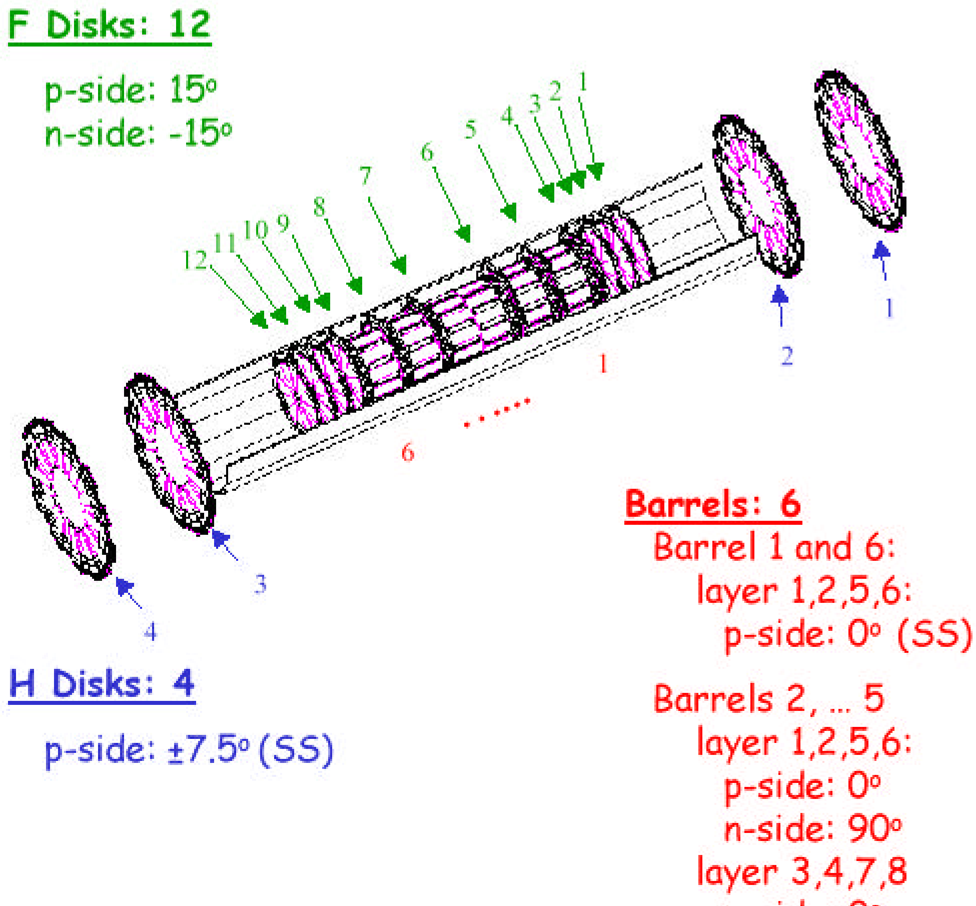
1. The south truss will not move down to the south sidewalk in preparation for installation until some time in January 2001. It is rolled into the Collision Hall last – after the north truss and the platform – allowing for disconnection of the helium engines, if it is needed, after the full detector is commissioned as fully as possible prior to roll-in.
2. There are a total of two platform moves including the final move into the collision hall.
3. Uninterrupted commissioning can start in July 2000 and will end when the detector is rolled into the Collision Hall, offering a total of more than six months of detector commissioning time during the end game.

Implications of the Scheme II schedule:

I. We rely on the Tevatron commissioning run ending at the end of October 2000.
II. The liquid helium engines will be interrupted at most once and this will be in January 2001, with the same caveats applying here as to Scheme I above.

With this fallback schedule we will have created about two months of contingency for the delivery of the silicon tracker and the completion date for the detector is now February 21, 2001. To take full credit for this contingency implies that the ECS (and preshower/ICD) hookup has to be done partially when the detector is in the collision hall.

Silicon Microstrip Tracker



	Barrels	F-Disks	H-Disks
Channels	387120	258048	147456
Modules	432	144	96
Inner R	2.7 cm	2.6 cm	9.5 cm
Outer R	9.4 cm	10.5 cm	26 cm

As shown above, the baseline Silicon Microstrip Tracker (SMT) consists of six barrel assemblies with interleaved small disks ("F-disks"), together with additional F-disks in the forward/backward regions. There are four separately supported large disks ("H-disks") upstream and downstream. Each barrel has 4 layers, with 12 ladders in the innermost two layers in radius, and 24 ladders in each of the outer two radial layers. The outer two barrels in |z| (labeled 1 and 6 above) have single sided, axial strip detectors in radial layers 1 and 3 ("3-chip" ladders). The inner four barrels (2-5) have double sided, double metal, 90-degree stereo detectors in layers 1 and 3, with a two-fold readout ambiguity for the 90-degree strips ("6-chip" ladders). Radial layers 2 and 4 use double sided, small angle stereo detectors ("9-chip" ladders) in all six barrels.

Areas of schedule concern for the SMT are

- Ladder and wedge construction rates and yields.
- Testing and debugging time and effort at SiDet: unanticipated detector problems have made this a protracted process.
- Parts availability, of sensors from Micron, of HDI (high density interconnect) assemblies, and of sufficient SVX II chips.
- Final assembly effort and engineering.
- Installation.

The possible fallback and descoping options are quite constrained by the design of the detector. The SMT is a highly intricate, non-modular device. We do not anticipate being able to change anything in the central barrel-disk assembly after it is installed, nor could we add (for example) the end F-disks after installation. The H-disks, on the other hand, are accessible and could be installed later. It should be noted that the central F-disks (those interleaved between barrels) and the forward ones have different electromechanical connections, and cannot be exchanged after they have been built. Most of our discussions have focused on the 90º stereo detectors and the F-disks, as will be explained below. Our overall emphasis has been to minimize the risk of compromising the central ($|\eta| < 2$) region, since this is where the majority of our high-priority physics lies (top, W, Z, SUSY, and Higgs). We have discussed some other options which did not appear very attractive to the SMT group. A reduction in the number of barrels is not considered a viable option; the number of barrel layers cannot be reduced without impacting track reconstruction.

Installation Scheme

In the last few weeks we have begun to explore an alternative installation technique for the SMT detector, which appears most promising. The baseline installation scheme called for the SMT to be installed as a single unit, which required that one of the end-cap calorimeters be removed from the detector platform and that the detector be in the assembly pit rather than the collision hall. The proposed new scheme involves splitting the SMT into north and south halves, each with its own support cylinder. We believe that the resulting half-detectors are short enough to be installed in DØ in the configuration with both end-cap calorimeters on the platform (though retracted). This procedure could even be done with the detector already rolled into the collision hall, since the beam-pipe sections can be retracted sufficiently in situ. This scheme would permit later installation of the SMT, generating considerable additional schedule contingency. The second half-cylinder could arrive as late as January, 2001 and still make the March 1 data-taking. This new approach adds significant flexibility to the installation sequence. It is also attractive because it would later allow maintenance access to the detector while it is in the collision hall, for repairs, monitoring, and even potential replacement of devices. On the negative side, it forces changes to the cooling system and requires supports near $z = 0$. These supports must maintain alignment between the two halves, without introducing any gap. The split-cylinder concept is now being aggressively pursued, with the hope and expectation that it will become our new working baseline.

Engineering support must be devoted to fully understanding this concept. We believe that the gains from this approach are so dramatic that it should be pursued wholeheartedly and immediately. The original scheme remains available as a fallback.

Production Rates

The SMT group reaffirms that in its opinion, all needed ladders and wedges can be produced in time for an on-schedule completion of the tracker. We have the capability to deliver sufficient detectors in time, even if we

a) include the foreseeable production gaps due to HDI component delivery schedules,

b) slow the rate of 6-chip ladder production to match the (slower) rate of 9-chip ladder production and
c) even allow for an additional and unforeseen one-month hiatus in production.

Single-sided barrel detectors

The "3-chip" ladders (single-sided barrel detectors) are two-thirds complete, are straightforward to build, and are at very little risk. The first barrel assembly, consisting of 72 ladders and using single-sided detectors in layers 1 and 3, will be assembled within a month.

90º barrel detectors

The "6-chip" ladders (90 degree stereo barrel detectors) are limited by sensor delivery rates from Micron. The delivery rate needed is ~10 per week (in January, Micron delivered only 12). Yields of good detectors are low, but there do exist substantial numbers of lower quality sensors (with noisy regions of 5-15 neighboring strips on the 90 degree stereo side) that could form part of a fallback plan. There is also a very large number of devices (600) currently in the manufacturing process at Micron, and we are setting up a second production line in Lab A for 6-chip ladders to enable us to cope with the anticipated large influx. These ladders are composed of a single sensor each.

The possibility of purchasing new single-sided detectors to replace the 90º stereo detectors has been considered. This was also suggested as a way to increase the radiation hardness of the device, which would be a benefit, though it assumed that the 90º information could be sacrificed without serious physics impact. However the production lead times, availability of components, and cost make this prohibitive. The DØ SMT group believes that there is no compelling reason to abandon 90º detectors at this time.

The preferred fallback is therefore to install poorer quality 90º detectors. The optimal way to deploy such detectors, so as to minimize the impact on the physics, is under study. Operating the poorer quality (noisy) 90º detectors as single-sided devices (reading out only the axial strips) is another option, were it to be shown that this would improve the radiation hardness of the devices (and again, that the 90º information could be sacrificed without serious physics impact). Such studies will also be conducted.

Small Angle Stereo Barrel Detectors

The "9-chip" ladders (small angle stereo barrel detectors) are the slowest devices to assemble, so production rates are a potential concern. If yields are low, availability of sensors and HDIs may be a problem. These detectors cannot be replaced by other devices. Consequently the fallback is to accept lower grade units.

F-disks

The F-disk detectors have suffered from low yields of HDIs, which are especially complex and fragile for these devices. We have already placed an order for additional HDIs to address this problem. The delivery of the silicon sensors is not a significant risk: recent yields from Micron have been excellent, and if this is maintained they will produce about 15-20 wedges more than the 125 that were ordered. There is also a second F-disk order, for 75 wedges from Eurisys. They have delivered devices with some small problems so far, but are still ramping up production. The total needed is 144.

If F-disk assembly is delayed, we could opt not to install some of the F-disks. This decision does not need to be made before March, 2000 (and perhaps later, depending on the schedule contingency available).

One could imagine omitting the four central F-disks (those interleaved between the barrels). If this option is pursued, one might wish to close up the resulting ~8mm gaps between the barrels, though the support structure configuration would have to be changed accordingly. The deadline for such a decision is likely to be around the middle of May. Alternatively, one could omit some (perhaps two at each end) of the forward F-disks. This question will receive input from physics studies.

H-disks

The "H-wedge" (large disk) detectors are halfway complete and proceeding smoothly, though production will be paced by the availability of HDIs. Staged installation of the H-disks is a viable option, but it only makes sense to delay them if resources would be freed up.

Availability of SVX chips

The availability of the SVX-II front end chips, which are attached to the HDIs on the detectors, is a concern. By our present accounting we have just about sufficient chips to instrument the full silicon detector and the other devices that use this readout in DØ (the fiber tracker and the preshower detectors). This total includes the wafers that were "banked" with UTMC at the time of manufacture.

The most straightforward way to increase the number of chips available is to repair failed HDIs, and this is already underway. A non-negligible number of chips have been rejected at Promex (the HDI assembly vendor) for visual defects; these chips will be reinspected and classified. So far, only "A" grade chips have been accepted; "B" grade devices will also be tested to see if they can be used — if not in the SMT, then perhaps in the fiber tracker and preshower detectors, where they could be installed later since they are not mounted in the tracker cavity. We will also attempt to salvage chips from non-working HDIs, though removing chips is problematic at best. If these measures are not sufficient, we would have to omit detector elements, guided by the physics impact.

Plans

We believe that the full SMT detector can be built by the September 18, 2000 milestone date. We have not taken any credit for the additional 6-8 weeks of schedule contingency beyond this date in the current schedule, nor for any additional slack generated by the new split-cylinder installation scheme. We need to devote additional engineering effort to understanding the new installation sequence, and it needs to be integrated into the DØ installation schedule. While we have been able to generate considerable schedule contingency, we may still need to reduce the scope of the detector. This could occur, for example, because of the SVX chip availability. We are therefore carrying out studies of the physics impact of the various reduced disk and stereo configurations, on both track-finding and vertexing capabilities, for top and B-physics events. We are employing tools ranging from simple geometrical arguments, through parameterized simulations, to full GEANT with the Run II C++ track finding and fitting code. We are also attempting to establish decision dates by which such options might need to be exercised.

Fiber Tracker

For Run II the central fiber tracker (CFT), combined with the solenoid, will be the most crucial new sub detector that is installed in DØ. It enables us to trigger on tracks, point tracks into the silicon detector, is needed for alignment of other detectors and, last but not least, for calibration of the complete calorimeter system. The innermost CFT cylinder (cylinder number 1) forms the support system for the SMT and the construction of the CFT requires *all* eight CFT cylinders. Each of the eight cylinders has an axial and stereo layer of 800 μm diameter fibers, mounted on the outside of the cylinder, with the axial layer being the innermost one. Given the above, there are no fallback options for the CFT. All eight cylinders must be constructed, nested and installed in DØ, before any other part of the inner tracking system can be installed.

Light from the fiber tracker is transported via clear optical fiber waveguides to the VLPC cassettes underneath the detector platform. Because the waveguides are fragile and have to be carefully routed, they are installed after the CFT is installed. Pre-installation has been considered and is a very unlikely and difficult option. The waveguides have to be installed before the cabling of the silicon detector starts because the cables of the SMT are routed on top of the waveguides, on the face of the central calorimeter cryostat. Because of this constraint no fallback options are available for the waveguide installation. It has to be complete by the time the SMT starts hooking up, although there is a little bit of contingency here, because there is a north and south side to the trackers and SMT hook up will start on one side first. During that time waveguide hook up can continue on the other side (for about 2 weeks).

The waveguides terminate in VLPCs which are housed in cassettes operated at liquid helium temperature. Each cassette has 1024 VLPC channels; the necessary readout and trigger electronics is mounted above the VLPC cassettes and is at room temperature. The standard schedule has these items installed in time for commissioning. In case of a delay in either the VLPC cassette production or in the associated electronic boards, the fallback option is to install these items later. Here later can extend up to March 2001 and beyond, because cassettes could even be installed while the detector is in the collision hall during a few day shutdown period of the accelerator. A few days are required to warm up the relevant sections of the cryostats which house the cassettes, so that additional cassettes can be installed.

Central and Forward Preshowers

The Central Preshower (CPS) is already installed. It has similar waveguides to the CFT and shares the same readout system. Because it is on the outer perimeter of the solenoid, the waveguides for the CPS have to be installed before the CFT waveguides. There are no fallback positions for the waveguide installation. The same fallback options exist for the VLPCs and the electronics, as for the fiber tracker.

The Forward Preshower (FPS) is mounted on the face of the north and south calorimeter end-caps. The detector is almost complete and is not a schedule risk. Waveguides for this system run on the end-cap calorimeter faces and do not interfere with the central tracking system. Fall back positions for the waveguide installation could extend to March of 2001 and even beyond. For electronics and VLPCs, see the fiber tracker section.

Tracking Electronics

Tracking electronics is needed for cabling up CFT, CPS, FPS and SMT, as well as for commissioning them. If the electronics is late we would shorten the commissioning time, use prototype electronics to check out connections while cabling and hooking up the detectors and if necessary move crates from one place to another. The priority in terms of having electronics available is:

1. Axial readout for CFT (provides trigger)
2. Readout for SMT
3. Readout for stereo CFT
4. Readout for CPS, FPS.

These priorities are essentially already in effect now.

Calorimeter

Calorimeter Electronics

Since the calorimeter cabling has remained essentially unchanged for the upgrade, the central calorimeter (CC) and the north end-cap calorimeter (ECN) only require that the preamps and baseline subtractors (BLS's) be installed in order to start commissioning. The south end-cap calorimeter (ECS) is not on the platform now (and hence is completely uncabled). Once it is moved on to the platform it will need to be cabled up. All calorimeters require new preamps (located near the top of cryostats) and BLS's (located underneath the platform) to be installed and checked out.

Both the CC and ECN are expected to be instrumented by October 2000, filled with liquid argon and in a commissioning phase. The ECS is moved to the platform in the beginning of November 2000. It is then cabled and preamps are installed. BLS's could have been installed earlier if available.

Since, if necessary, both preamps and BLS's could even be installed in the collision hall, there is a viable fallback option. Not having the electronics available before roll in would simply decrease or eliminate the commissioning time. Since the BLS's are located underneath the platform, they can be accessed during short down times. The installation of the preamps in the collision hall will require the detector to open up and such operations would take at least a full day access if they were installed after March 2001. A summary of the fallback positions and risks is provided in the following table:

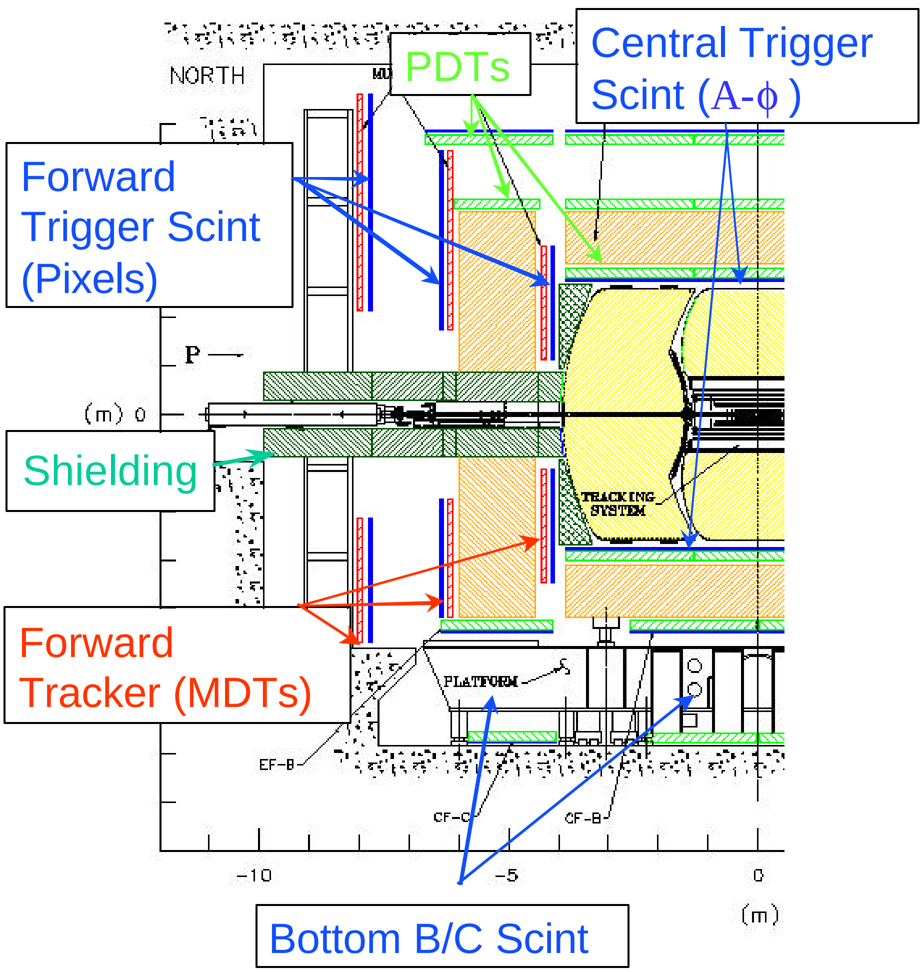
System	Schedule Risk	Risk assessment	Fallback Plan	Decision Date
CC, ECN Preamps	Late delivery	Low	Install in collision hall	1/01
ECS cabling	ECS not available due to silicon installation delays	Medium-high	Install in collision hall	1/01
ECS Preamps	ECS not available due to silicon installation delays	Medium-high	Install in collision hall	1/01
ECS Preamp power supplies	ECS not available due to silicon installation delays	Medium-high	Install while ECS is off platform	9/00
BLS's	Late delivery	Medium	Install in collision hall	1/01
BLS power supplies	Slow construction	Medium	Install in collision hall (difficult due to power supply weight)	1/01
Full commissioning completed	Electronics not installed, or silicon installation delayed	Medium-high	Commission with beam in collision hall	3/01

Inter-cryostat Detector

The inter-cryostat detector (ICD) is mounted on the face of the north and south end-cap calorimeters. The readout is part of the calorimeter system although this detector is not part of the Level 1 and Level 2 calorimeter trigger. The ICD construction is progressing on schedule. The ICD can be installed with all detectors on the platform. Fallback positions range from a delayed installation, which would shorten commissioning, to the extreme position where the ICD could be installed and hooked up when the detector is in the collision hall. Installation requires the central calorimeter to be in its open (access) position.

Since the readout system is the same as the calorimeter readout system, the fall back positions for the ICD are identical to the ones described above for the calorimeter.

Muon System



Central Muon System

The central muon detectors are completely installed and all modifications necessary for Run II have been completed. This includes the replacement of the strips which measure the position along the wire in the PDTs, completion of the cosmic ray scintillator and installation of the A-ϕ scintillation trigger counters in the central region. The only part of the subdetector currently unfinished is the gas recirculation system, which is in the process of being assembled. We see no schedule risks in this system and therefore fallback positions are not needed. If for some reason the gas system were not to be completed, we could in principle run using gas bottles without the recirculation system.

The central muon system is currently being commissioned and is the detector system which dictates the pace of the commissioning efforts and what is needed from the online, trigger and DAQ systems.

Forward Muon System

The forward muon system consists of three layers of detectors, A, B, and C, and is located at the north and south ends of the experiment. The A layer is just outside the calorimeter and inside the muon toroid. The B layer is mounted on the outside of the toroid and the C layer is mounted about another meter further away on the outside of the toroid. The above figure shows an outline of the muon system. Each layer consists of a plane of trigger pixels, which are scintillator tiles of size $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ and which provide a fast trigger signal. This trigger plane is followed by a plane of Mini Drift Tubes (MDT) and each MDT plane consists of three or four layers of MDT detectors. The trigger pixel scintillators were all constructed at IHEP (Protvino) and are all at Fermilab. The MDTs were constructed at JINR (Dubna). Layers A and C of the MDTs are at Fermilab and layer B is in transit and should arrive in March. The trigger pixel counters and the MDT tubes are assembled into octants at Lab F at Fermilab. Subsequently these octants are assembled into large detector planes in the DØ hall as part of the detector installation.

Pixel status: Pixel layers A & C have been completely assembled and 16 octants exist for each layer. The B layer is currently being assembled into octants and will be complete by the end of February 2000.

MDT status: For MDTs the A layer octants have been completed and are under test. The B & C layer octant assembly is scheduled to start in early March.

Installation status: None of the planes have been installed in the detector yet, but the forward muon system is on schedule and we anticipate that it will stay that way.

The forward muon installation requires large objects to be manipulated in the very tight DØ assembly area. Therefore the installation sequence of this system is influenced by the central tracker (SMT and CFT) installation schedule as well as the general installation sequence of the whole detector. Because of these constrains and using Scheme I as our installation sequence, we have defined priorities for this system which can be summarized as follows:

1. Complete the B layer trigger pixel octant assembly.
2. Install the A layer pixel & MDT octants on the detector.
3. Complete the C layer MDT octant assembly.
4. Install the south C layer MDT & pixel planes on the south truss, to be ready for roll into the collision hall in August 2000 (see installation Scheme I).
5. Complete the B layer MDT octant assembly.
6. Install the south B layer MDT & pixel plane on the detector.
7. Install the north C layer MDT & pixel plane on the north truss.
8. Install the north B layer MDT & pixels on the detector.

These priorities also define the fallback plans for this system. We expect that the B layer pixel octants will be finished on schedule and pose no schedule risk. We are still awaiting vendor delivery of the support panels for the B & C MDT supports and have had difficulty acquiring panels that meet our flatness requirements. This poses some medium schedule risk, although we believe that the panels which will arrive on February 9 will meet our needs. In any case we have decided that they will be made to work as support panels. This affects only the B & C layers, and that is one of the reasons why our fallback installation sequence is Scheme II, which does not require C layer MDT octants until later this fall. In case we should encounter difficulties in this respect, as indicated above, the C layer would have higher priority in terms of octant assembly and installation. In this scheme the B layer would be delayed. The extreme fallback position would be installation sequence Scheme II with the B layer plane not installed by the time the detector rolls in. In this case we would start Run II without the B layer. It would be installed during a future shutdown in Run II and it would require the shield wall to be taken down, but we believe that this could be done with the detector in the collision hall.

Muon Electronics

The muon electronics has been delayed compared to our original baseline schedule, but poses no threat for the March 2001 ready-for-beam date. These delays have not yet shortened the commissioning time available, but any further delays in the next few months would result in less commissioning time for the central muon system. At this point we see the schedule risk due to the muon electronics as minimal. In case this evaluation is wrong, the extreme fallback position would be to complete any missing electronics during shutdowns early in Run II.

Trigger

The trigger system consists of 4 levels:

1. The inelastic interaction trigger, Level 0
2. The Level 1 trigger, which uses information from CFT, CPS, FPS, calorimeter and muon system.
3. The Level 2 trigger, which essentially uses the same information as Level 1 (with the addition of the silicon) but now can correlate the information from these systems.
4. The Level 3, which is a PC farm based trigger, where the full readout from all detectors is available.

The trigger framework has been at DØ for many months now and is being used to run cosmic ray triggers for commissioning of the central muon system. The trigger system is on schedule and most of its components are located outside the collision hall, so that work, development and implementation can continue after the detector is rolled in. This is especially true for Level 2 and Level 3, which are entirely software based triggers. Even Level 1 is to a large extent programmable, but some of the signals needed for Level 1 are generated on the platform and use electronics located on the detector platform. We foresee no problems with the muon and calorimeter Level 1 triggers in this respect. However the Level 1 tracking trigger (CFT, CPS and FPS) use electronic boards for which prototypes are not yet in hand (8MCM and 12MCM analog front end boards). The 12MCM boards are not designed and here we are waiting for the 8MCM prototype versions to be tested, because the two boards are closely related. These boards are mounted on the VLPC cassettes and can be installed after the detector is rolled in. The highest priority is to complete the 8MCM boards, because they read out the axial CFT fibers, which form the CFT track trigger at Level 1. The 12MCM boards read out part of the stereo CFT layer (not in the Level 1 or 2 triggers) and the CPS and FPS. If the 12MCM boards are late, we will start Run II without them and install them during short shutdowns at the beginning of Run II. Until the 12MCM boards arrive we would not be able to include the FPS and CPS in the Level 1 and 2 trigger and a portion of the stereo CFT would not be available at Level 3.

As already mentioned above, large parts of the trigger system are accessible and are downloaded at the start of each run. So parameters and functionality of the trigger can be changed as conditions change and therefore the trigger system will go through a continual evolution into the final Run II system. The start of this evolution will be during the commissioning time this year and continue into Run II. There is enough flexibility in the trigger system that it is not a schedule risk for the start of Run II in March 2001.

Online

All functionality required from the online system for Run II has been implemented in at least a rudimentary way. The individual components may not be able to handle the data rates expected during Run II, but their functionality exists and enables us to start commissioning the detector. As the requirements from the commissioning efforts demand increased capabilities, these will be implemented. Based on previous performance we see no difficulty in obtaining the complete functionality needed in the online system by March 2001. Even more so than the trigger, the online system is not a schedule risk for the start of Run II, because the basic functions needed to start Run II are already available today. The fallback option is that we start Run II with less bandwidth than we had anticipated and increase our online bandwidth and capabilities as the detector and accelerator performance improves.

Solenoid

The solenoid is installed, has been operated and should present no schedule risks or uncertainties. Like all other cryogenic devices, it can be operated in the assembly area and in the collision hall.

Summary

We are fully committed to the DØ detector being rolled in and ready for data taking on March 1, 2001. We believe that we have already benefited substantially from the exercise of examining fallback options. Since the December 20 letter was received, we have settled on a new sequence for installation, which has the effect of generating an extra six to eight weeks of schedule contingency for the completion of the silicon tracker. We have made a working decision to adopt a new installation scheme for the silicon tracker which has many advantages, including additional schedule contingency. We have changed the priorities in the forward muon system production so that the B-layer will be completed last. And we have engaged the collaboration in a serious and informed discussion. We will now integrate these options into our planning, continue with physics studies, and attempt to establish decision dates at which such options might need to be exercised.

Appendix: The Fermilab schedule

October 15, 1999

October 1999 to March 2001 Schedule

CY	1999			2000								
Month	Oct	Nov	Dec	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
Proton Source	M&D	Operation			M&D	Operation					M&D	Run II Commissioning Run
Main Injector	M&D	Operation			M&D	Operation					M&D	
Recycler	Bake out	Installation and Commissioning			M&D	Commissioning		Engineering Run			M&D	
Pbar Source	M&D	Commissioning	a)	E835 Run	M&D	E835 Run		c)			E-835 Removal	
Tevatron	1 TeV test	Operation		b)	Changeover to Collider Configuration			Run II Engineering Run			Detector Roll-in	
Switchyard	M&D	Operation			OFF							

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CY	2000			2001		
Month	Oct.	Nov.	Dec.	Jan.	Feb.	March
Proton Source	Run II Comm. Run	M&D/Studies/Commissioning				Run II
Main Injector		M&D/Studies/Commissioning				
Recycler		M&D/Studies/Commissioning				
Pbar Source		M&D/Studies/Commissioning				
Tevatron		CDF Roll-out & Roll-in and D0 Roll-in				
Switchyard	OFF					

a) Band 1 & 2 Installation and E835 installation

b) Possible KAMI Test

c) Operation for Pbar Source Commissioning, Recycler Engineering Run, and parasitic Run of E835